

University of Cambridge
School of Agriculture Memoirs

Memoir No. 20

A summary of the papers published by the members of the Staff of the School of Agriculture and its Associated Research Institutes during the period Oct. 1st, 1947—Sept. 30th, 1948.

Review Series

No. 3. Plant Breeding Institute :
Historical Review, 1912—1948.



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FOREWORD

This Memoir, which is published under the general editorship of the Librarian of the School, represents an attempt to present as succinctly as possible the contributions made by members of the Staffs of the School of Agriculture and its Associated Institutes to the development and progress of Agricultural Science, to indicate to research workers interested the Journals in which the full papers are presented and to act as a complete record of papers published. Each summary is compiled by the author of the paper and is presented, so far as the subject matter will allow, in a non-technical form in order to be of value to the general body of farmers interested in the more recent developments of agricultural scientific research in general and of the activities of this Department in particular.

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PLANT BREEDING INSTITUTE: HISTORICAL REVIEW, 1912—1948*.

By

G. D. H. BELL, Ph.D.
(Director, Plant Breeding Institute)

Although the Plant Breeding Institute was not set up until 1912, two years after the formal opening of the School of Agriculture, genetic and plant breeding work had been started by Biffen, who became the Institute's first Director, some years previously. Indeed it was Biffen's early work on genetics that was the original inspiration for the establishment of the Institute, and the official action may be taken as a direct recognition of the great significance of Biffen's investigations which had demonstrated the possibilities of applying the new genetic knowledge to the breeding of agricultural plants. These investigations showed that the recently re-discovered researches on heredity by Mendel had more than a limited academic interest, and promised to usher in a new era in plant breeding. Although the optimistic attitude that was fostered by some geneticists at that time and later, has not been fully justified, it still remains true that Mendel's original work, followed by that of Biffen and the other earlier workers who appreciated its significance, marked the beginning of a new approach to plant breeding.

In 1904 Biffen published his first paper on hybridisation in wheat and barley thereby demonstrating Mendelian inheritance in these crops (1). This was followed quickly in the next few years not only by further researches on inheritance by Biffen, but also by his ready appreciation of the practical implications which led to the first applications of genetic knowledge to plant breeding (2-9). These genetic researches not only demonstrated a Mendelian basis for the inheritance of a number of morphological characters in wheat and barley, but more significantly showed a similar basis for the inheritance of resistance to disease as exemplified by the reaction of wheat to Yellow Rust (*Puccinia glumarum*). Thus by 1907 Biffen was able to talk about "modern plant breeding methods" with special reference to wheat and barley (10), and a few years later his investigations were being centred on the problem of disease resistance and baking quality in wheat (11-15).

The very rapid practical applications of this work are shown by an account in the Journal of the Board of Agriculture 1911-12 which refers to the cereal breeding work on the College Farm, land having been made available for this work when the School of Agriculture took over Gravel Hill Farm in 1910, although previously facilities had been provided on Burgoyne's Farm. By this time "two useful varieties of wheat, one rust-resistant and a prolific yielder, and the other a strong wheat combining the quality of Fife and the cropping capacity of the best English varieties" were said to be fully established on a field scale, and attempts were being made to combine the desirable characters of these two varieties. Although the first named variety—Burgoyne's Fife—which combined good baking quality with certain desirable characters for an English wheat, later proved to be an uncertain yielder and did not survive in cultivation, the possibilities of improving wheat by systematised breeding had been amply demonstrated.

Although Biffen paid some attention to spring wheats (16, 17), and genetic investigations continued as an integral part of the work of the Institute (18), his investigations continued to be concentrated principally on plant breeding methods in winter wheats and their improvement through disease resistance and baking quality (19-21). In an account of this early work (19) Biffen states how his investigations owed their origin "primarily to a desire to know whether Mendel's now well known laws of inheritance applied to other plants than the various kinds of peas he used in his experiments. It developed rapidly in directions unforeseen at the time . . . Now it has become almost a matter of routine." These few words convey inadequately the years of research which led to the establishment not only of a method of breeding from fundamental scientific enquiry, but also to the first practical achievements in the form of two varieties of wheat—Little Joss and Yeoman.

Little Joss, obtained from a cross between Squarehead's Master and Ghirka, inherited Yellow Rust resistance from Ghirka and has found a place in British agriculture as a variety suitable to lighter soils as well as being popular in the Black Fen. Yeoman, resulting from a cross between Browick and Red Fife, finally demonstrated that high yielding, good baking quality wheat could be grown in this country, that certain types of baking quality were inherited in a straightforward manner, and incidentally that the scepticism on the part of the milling and baking trade and of certain farmers, was unfounded. This variety, which is still grown, was made available to growers in 1916 and has since been the basis of breeding work for baking quality of home-grown wheats.

Biffen's pioneer work on genetics in cereals was later amplified, as the science of genetics developed, by Engledow (22-27). These researches included the study of what were then the newer concepts of multiple factors in inheritance and the use of metrical methods in genetic analysis. Engledow's mathematical and analytical approach to the study of botanical and agricultural problems particularly involving yield, led him to undertake a long series of investigations concerning the factors underlying yield in the field. The studies initiated, and carried on in collaboration with other workers, by Engledow, were inspired by the desire to introduce a statistical basis to the analysis of yield, and the work gave considerable impetus to a more exact study of the growing plant as reflected by the end product in terms of yield (28-39).

As Biffen's work laid the foundations for the genetic approach to plant breeding, so did Engledow's initiate a developmental and physiological attack on the plant breeder's material. The resolution of a complex attribute such as yield into its morphological and developmental components is the basis not only of yield as a plant "character", but is necessary for an understanding of crop yields in the field and such important problems as

* This is the third of a series of articles summarizing phases of agricultural research particularly associated with the School of Agriculture since its inception. Further contributions on other work will appear in future issues.

varietal adaptation. Engledow's work, therefore, did much to clarify the position with regard to supplying a working hypothesis for breeding for yield, and introduced new ideas in this respect particularly for wheat. But of equal significance was the carrying of this work into the field crop, with its important repercussions on yield analysis and crop testing which were reflected in the development of field experimentation not only as a plant breeding technique but as a tool for crop husbandry research (40).

By 1926 the Institute's work had expanded to include wheat, barley, oats, field beans and field peas. In particular Hunter was developing winter-oat breeding, as well as commencing investigations on the possibility of selecting more winter-hardy field beans. Hunter's early work at the Institute was, however, of principal importance for the progress made in winter-oat improvement, which was achieved by hybridising winter and spring varieties and later led to the introduction of varieties for winter sowing. The great difficulty which the breeder has to face in the improvement of winter oats is not only the very restricted number of winter varieties which can be used, but also that winter-hardiness does not show such a strong expression in oats as it does in wheat and barley. The most winter-hardy oat varieties are the types with grey grain typified in this country by the variety Grey Winter, but this variety, although showing excellent grain quality in terms of low husk percentage, has a weak straw and is not a high yielder. It is consequently necessary to hybridise Grey Winter types with spring varieties to obtain the combination of winter hardiness with other desirable characters. Hunter chose an Argentine spring oat with a short, stiff straw for his initial work in hybridisation with Grey Winter, and eventually selected from the progeny a culture which was put on the market in 1934 as the variety Resistance. This variety however, although possessing very strong straw and the capacity to give high yields of quite good grain on rich soils, did not possess the winter-hardiness of Grey Winter, and it was subsequently grown as a variety for early spring sowing. Subsequently, in 1940, the variety Picton was put on the market. This was selected from the same cross, possessed a winter-hardiness comparable under most conditions to Grey Winter, and although not as short and strong in the straw as Resistance, was a considerable improvement on its winter-hardy parent in field characters (41).

As mentioned above, Hunter interested himself also in the improvement of winter beans. A rather more winter-hardy type was selected, but there was so little interest shown in the crop at that time, that the work passed practically unnoticed. In addition, Hunter started the first work on the improvement of sainfoin which laid the foundation for the development of arable forage crop breeding which was to be later developed at Cambridge.

Hunter's name, however, will always be associated with the barley crop, and his work in Ireland before coming to Cambridge had established him as the leading authority on this crop in the country with E. S. Beaven. Hunter's earlier publications on barley, his books on the barley crop and the oat crop, and his contributions to the study of other crops such as flax, were the result of his pre-Cambridge activities and do not rightly belong to this account of the Institute's work. In 1931 Hunter made a most valuable contribution to agricultural literature by editing a new edition of Baillière's *Encyclopaedia of Scientific Agriculture*, a work which formed a counterpart in another sphere to Biffen's edition of *Fream's Agriculture* which appeared in 1932. Two years later Hunter collaborated with Leake in writing an account of *Recent Advances in Agricultural Plant Breeding*, a book which is still a standard reference for the period which it covers (42).

Hunter's researches at the Institute in the 1930's included some important studies on breeding and physiological problems in relation to malting barley (43-45) and these were continued in the war years (1939-45) when he was Director of the National Institute of Agricultural Botany as well as of the Plant Breeding Institute, the latter appointment having taken effect from 1936 when Biffen retired. The barley investigations did much to elucidate the developmental phenomena underlying yield and malting qualities in the typical spring varieties of malting barley grown in this country. In particular, the relationship between tillering, ear survival, fertiliser treatment and yield and grain quality were studied, with a consequent better understanding of varietal behaviour. This particular interest, and a wider general interest in the developments of plant breeding and their impact on agriculture, led to the publication of several papers and contributions on crop improvement, suitable varieties of cereals for sowing in this country, and seed certification (46-53).

Meanwhile in the sphere of practical barley breeding, Hunter continued to make contributions. In 1943 the variety Camton was put on the market. This was derived from hybridising Spratt with Archer-Goldthorpe, and was intended as a feeding barley, with sufficiently strong straw to stand up to really fertile conditions, and has since found a place in dredge corn and other mixtures. More recently an early selection of Spratt-Archer (also bred by Hunter) was marketed under the name of Earl. This variety, which was released in 1947, ripens about 7 days earlier than Spratt-Archer, but otherwise has similar characteristics.

When Hunter resigned from the Directorship of the Institute in 1946, Bell was appointed to act as Director, and in 1948 with the announcement by the Agricultural Research Council of the development of a larger and independent Institute, he became full-time Director. Bell had been doing research in the Institute on barley and field peas with the addition of sugar beet since the early years of the war. As a result of systematic study of cultivated barley varieties, he published a classification based on vegetative, developmental and grain characters, of virtually all the named varieties of barley known in the country (54, 55), an account which served as a companion to Hudson's classification of wheat which had been published earlier.

Some of the early work on the vernalisation of cereals, a subject which was attracting considerable attention in the early 1930's as a result of the Russian investigations, was done by Bell (56-59). He confirmed the effect of low-temperature grain pre-treatment on varieties of wheat, barley and oats, in that winter varieties could be stimulated in their development by such treatment, but failed to find any support for the view that there was any large-scale field application for the technique to cereal crops. This physiological work, associated with a study of hybrid progenies in barley, led Bell to a study of the date of ear emergence with particular reference to the inheritance of this character in relation to the physiological characteristics of the parents and the effect of time of sowing (60). This work indicated the inadequacy of the concept of date of ear emergence

as a single plant character and the necessity of a physiological resolution of such complex characters for a proper study and interpretation of genetic phenomena. Further genetic work aimed to study the inheritance of quantitative measurable characters was interrupted by the war, but Bell and Carson showed that the rachilla length of the barley grain was a heritable character (61).

During the period of the six or seven years prior to the 1939-45 war, the plant breeding activities of the Institute were developing on the three major cereal crops and also on field peas. Engledow had selected a new variety of Maple pea—called Marathon Maple—which was a high yielding, late-maturing type and was marketed in 1937. Winter wheat breeding was being developed to cover not only baking and biscuit wheats, but also to study the possibilities of inter-specific hybridisation as a means of improvement. Carson was studying the improvement of winter oats with Hunter, and Hunter and Bell were developing new hybrids in spring barley, while Bell was working with winter barley and field peas.

The wheat investigations resulted in the production of four new varieties, two selections and two hybrids which were made available to growers a few years prior to, or in the early years of the war. The two selections were Squarehead's Master 13/4, and Rampton Rivet, both of which showed improvements in certain characters, particularly strength of straw, over the original stocks. The first hybrid, which was produced from a cross of Yeoman and White Fife, was a baking quality wheat named Holdfast. This variety showed new milling and baking quality features, in addition to being a good standing wheat capable of high yields on fertile soils, but has since shown a defect in a tendency to grain sprouting in wet harvests. The other hybrid, Steadfast, from a cross between Little Joss and Victor, was essentially a biscuit wheat for medium fertile soils.

The work on the barley crop was directed to three main ends—the improvement of the field characters of spring malting barley; the production of a winter-hardy malting barley; the production of a winter-hardy six-row malting barley. These investigations involved a large number of hybrids and a considerable amount of study on the developmental and field characters in barley.

The basis of the improvement of the spring barley crop has been, during the 1939-45 war and subsequently, the hybridisation of various standard varieties grown in this country with the Danish varieties Kenia and Maja. These two varieties while offering desirable field characters in terms of yield, shortness and strength of straw, and earliness, do not possess the type of malting quality which is looked for in English barleys. As a result of the many hybridisations, a new range of promising hybrids combining several desirable characters has been obtained. These are now in various stages of trial at the National Institute of Agricultural Botany, and their future depends on the results of extended field and malting trials. It is hoped to be able to offer the grower more suitable varieties for combine harvesting, and varieties which are not so liable to lodge as some of the established varieties at present grown.

The growing tendency on the part of farmers to sow some malting barley in the winter led to the attempt by Bell to breed a two-row malting barley possessing some winter-hardiness, a character not possessed by the standard spring sown varieties. With this object in view a number of hybrids were made between two continental winter-hardy two-row barleys and Spratt-Archer and Plumage-Archer. The selection work was done immediately prior to the war and during the early years of hostilities when exceptionally severe winters were encountered. It was found possible to select cultures with considerably higher winter-hardiness than the non-hardy parents, but possessing most of their desirable field characters and acceptable malting quality. Consequently in 1943, the variety Pioneer (Spratt-Archer x Tschermaks) was put on the market, this being the first two-row malting barley possessing winter-hardiness to be made available to growers in this country (62). This work is continuing and it is hoped to improve further this type of barley.

During the war it was considered that there was a place for a six-row malting barley in the agriculture of this country. Consequently hybrids between two-row malting barleys and six-row winter barleys were persevered with, and in 1944 the National Institute of Agricultural Botany decided to market the Plant Breeding Institute variety Prefect (Praecox x Spratt-Archer). The work on winter six-row barleys is now expanded to include the development of high yielding types with improved field characters for feeding purposes.

The problem of the unsatisfactory position of the two major leguminous pulse crops of this country—field beans and field peas—has commanded attention at the Institute for a number of years, but has been brought into special emphasis by the changed national economic position since 1945. These two crops have shown an alarming shrinkage in acreage for some years, but it is a matter of great importance that they should be re-established. Although the decline in field bean growing, particularly, can be traced in part to the unsatisfactory yields resulting from changed methods of cultivation, there is obviously room for plant breeding work.

The Institute is, therefore, engaged at the moment in collecting and investigating stocks of winter and spring beans with the first objective of classifying and sorting the material. Trials are being conducted by Fyfe to discover whether there are inferior stocks which should be discarded and superior stocks which must be selected and multiplied. When this preliminary work is finished it is proposed to engage in longer term breeding investigations to test the possibilities of producing field beans resistant to Chocolate Spot Disease (*Botrytis cinerea*) and to Black Fly (*Aphis fabae*), while the question of increased winter-hardiness in winter beans will also be resumed.

The field pea breeding programme has been advanced further than that of the field beans. Work has been in progress for several years to try and produce earlier-maturing and shorter-straw types to reduce the hazards and difficulties in the cultivation of this crop, while a further line of approach was to breed multi-podded types to shorten the period of flowering and ripening by concentrating a larger number of pods at fewer nodes. A number of hybrids was made between early-maturing foreign field pea varieties, multi-podded green pea varieties and short-straw early green pea varieties on the one hand, and selected commercial stocks of Dun and Maple field peas on the other. Selected cultures have now been in field trial at the National Institute of Agricultural Botany for two years, and it has been shown at the N.I.A.B. and at the Plant Breeding Institute

that it is possible to obtain types showing considerably earlier maturation without sacrificing yield. An interesting fact that has come out of small-scale trials is that early-maturing varieties may escape the worst of the field attack of the Pea Moth (*Laspreysia nigricana*) and, therefore, that losses from this insect may be considerably reduced by growing early-maturing forms.

More recently, the possibility of producing field peas with some winter-hardiness has been studied, and selections are being made within the Austrian Winter Pea for this purpose. It is proposed to try improvement by hybridisation of these winter-hardy selections with commercial selected types and Plant Breeding Institute hybrids.

In the beginning of the last war the Institute took over Salaman's potato material which he had been developing in an attempt to breed a variety resistant to Late Blight (*Phytophthora infestans*). The basis of this work has been the hybridisation of the commercial potato (*Solanum tuberosum*) with the wild Mexican species (*S. demissum*) which shows a very high resistance. The breeding scheme involves repeated back-crossing to commercial varieties while selecting for desirable commercial characters and resistance to Late Blight.

The development of seedling testing on a large scale for Blight resistance largely by Dickinson, in co-operation with Howard and Carson who were largely responsible for the breeding work, has resulted in considerable headway being made, though Salaman's pioneer work was obviously the foundation. A great number of seedlings, involving many new crosses, has been tested for disease resistance, and new resistant seedlings showing promising commercial characters are now being studied by Howard in collaboration with Barclay who is working on potatoes and mineral deficiencies. The work has been expanded and developed in Northern Ireland, where the co-operation of the Department of Agriculture and the noted potato breeder Mr. John Clarke, has been much appreciated.

The present position with regard to this breeding work is that seedlings resistant to the three important Blight strains—A, B, and C—occurring in this country are now sufficiently advanced for detailed tests on cooking quality, yield and time of maturity to be undertaken. The wild morphological characters of *S. demissum* have been bred out while retaining the Blight resistance, and new techniques for stimulating the retention of flowers and berries on commercial varieties so that they can be used for breeding have been developed.

The possibilities of improving the potato by breeding have been considerably improved by the establishment of the Commonwealth Potato Collection as the result of the expedition sent to Central and South America in 1938. This collection, which is housed at Cambridge, is administered by the Commonwealth Agricultural Bureaux and offers a wealth of variability which is being studied as potential breeding material. The collection was originally one of the responsibilities of the Director of the Institute, and although it is now essentially a Commonwealth Bureau activity, the potato breeders must continue to have the closest interest in this work.

Certain genetic problems have been studied by Howard and Carson, particularly the explanation of some "off-types" such as bolters (63-66), while the work is also being developed to include the study of certain viruses in the breeding programme. Other work, conducted by Bell and others (67, 68) with potatoes, included a study of the feasibility of using cut sets for seed, the best technique to use for this purpose, and field trials on different varieties planted with cut sets treated in different ways.

A further expansion of the Institutes' work took place during the war in connection with sugar beet, when the Institute was asked to co-operate in the work of seed production as a result of the cutting off of Continental supplies. This work was originally of a temporary and short-term nature, but has now taken a more permanent place with the other major crops. The emphasis on the nature and scope of the work has consequently changed, and investigations are not now directed to the short-term policy of seed production, but to more fundamental scientific problems relating to the breeding problems of sugar beet. However, during the time that sugar beet had been studied at the Institute, attempts were made from the beginning to investigate various physiological, developmental and morphological characters of the plant, in addition to the normal root characters, which would be of use in breeding. In addition, the wild *Beta maritima* collected around the coasts of this country has been studied as a possible source of breeding material.

These investigations have indicated the significance of such characters as cluster size and weight, number of seeds per cluster and germination behaviour in breeding work. The physiological work, including a study of the life cycle in relation to bolting, has resulted in highly bolting-resistant lines being isolated as a result of low-temperature and long-day treatment of seedlings. Bell and Bauer's work on these characters has shown that root criteria are inadequate for selection work (69-71) if any radical improvement is to be effected, while the outstanding problems for beet breeding are the development of bolting resistant strains for early sowing and the control of Virus Yellows by obtaining inherited resistance.

With the incorporation of potatoes and sugar beet into the Institute's breeding programme, two more important arable crops were added to the scheme of crop improvement, and with the development of lucerne and sainfoin breeding, the general scope of the work was much enlarged compared with the early occupation with cereals only. Although the development of lucerne and sainfoin breeding by Fyfe is only just getting under way again after the war, the scope for improvement is obvious when the possibilities of providing, for example, suitable strains of lucerne for grazing and for hay are considered.

In addition to the main breeding programme and the research connected directly with it, the Institute has always been concerned with fundamental scientific research on closely related subjects concerned with breeding or the plants themselves. This has already been reflected in the account of the earlier work of the Institute initiated by Biffen and carried on by Engledow, Hunter and others. In particular, of course, genetic work has been represented, and in some cases by workers who have not been directly concerned with the breeding investigations. Watkin's genetic and cytological work on *Triticum*, for example, made considerable contributions to the knowledge of this genus, and did a great deal to elucidate the evolutionary and systematic relationships of the cultivated wheats (72-81). The inheritance of characters in polyploid species systems,

and the cytological phenomena in the particular case of the *Triticum* species, were also problems that Watkin's work helped to elucidate.

Further genetic, systematic and cytological work of a parallel type has been done by Howard in the genera *Brassica*, *Raphanus*, *Nasturtium* and *Rorippa* (82-94). The particular value of these investigations has been in relation to the polyploid and systematic relationships of the cultivated forms of *Brassica* and *Nasturtium*, two genera which include farm crops such as the cabbages, swedes, turnips and kales and mustards, and the valuable watercress. In both cases the whole breeding systems and possibilities for improvement depend on the systematic relationships particularly with regard to chromosome numbers.

Other work by Howard has included the action of hormones on root and shoot development, and the use of heteroauxin in the production of tetraploid shoots on wound callus (95-97), while quite unrelated work on the woodlouse (*Armadillium vulgare*) has indicated the importance of out-breeding in maintaining the vigour and adaptability of a polymorphic species in which the sex mechanism produces broods of one sex only (98, 99). But of more direct application to breeding work have been investigations on chromosome irregularities at reduction divisions in hexaploid oats, where it has been demonstrated that in hybrids between certain spring and winter varieties, a good proportion of pollen mother cells contain univalents, which occurrence is responsible for the instability and occurrence of chlorotics in some of these hybrids (100). Contributions to cytology have also been made by Fyfe (101-103).

Apart from the early work on disease resistance by Biffen, and the Blight resistance investigations developed later, certain important fundamental research on obligate parasites has been associated with the Institute's breeding work. Dickinson has studied Orange Leaf Rust (*Puccinia triticea*), Powdery Mildew of wheat (*Erysiphe graminis*) and Downy Mildew of Sugar Beet (*Peronospora Schachtii*) and has shown them to be peculiarly sensitive to contact stimuli in relation to their direction of growth and morphological features shown in the host plant. In addition to suggesting means by which these obligate parasites may be cultured artificially by the use of suitable artificial membranes, Dickinson suggests that the severe natural attacks by such fungi may be explained by the reaction of the fungus to particular moisture conditions, as for example, epidemics of Powdery Mildew in dry seasons due to the particular reaction of their hyphae to the surface of water (104).

In April 1948 the Agricultural Research Council, the Ministry of Agriculture and the University of Cambridge announced that the Plant Breeding Institute was to be considerably expanded and set up as an independent A.R.C. research station as soon as a suitable site could be obtained. In the meantime the Institute is to remain at the School of Agriculture with its breeding plots on the University Farm, and the interim expansion has already entailed the taking in of more land to cater for the more pressing needs. Thus, after 36 years association with the School of Agriculture, the Institute is looking to a future which will mean greater opportunities, but at the price of severing a very happy and profitable connection during which the foundations of plant breeding were laid and the work developed to make its contributions to science and to agriculture.

It is going to be necessary not only to develop a new Institute in terms of land, laboratories and general facilities, but also to build up what is virtually a new staff of scientific officers, technical assistants and field workers. Already four new officers—G. K. G. Campbell, F. G. H. Lupton, S. G. Stephens and R. N. H. Whitehouse have been enlisted, and it is hoped to build up the staff over the next few years to cope adequately not only with the crops that are already being studied, but also those that are to be added.

It is proposed that the enlarged Institute should undertake work on all the important crop plants, with particular reference to the needs of the drier and more important arable areas of England. There will consequently be an expansion of the work on all the major arable crops now being studied, such as wheat, barley, oats, potatoes, sugar beet, beans, peas, lucerne and sainfoin, while new crops such as the field Brassicas and any others demanding attention, will be included. Already expanded programmes on some of the crops are under way, while long-term work on new breeding techniques such as the artificial production of amphidiploids in the *Triticineae* has been started (105). Entirely new problems will need tackling as, for example, the development of herbage plants for the drier parts of the country, so that the full range of crop husbandry requirements are being met. It will, however, be necessary not only to approach directly the agricultural requirements by means of a practical breeding programme, but as in the past, the association of pure scientific investigation and applied research must remain as an integral part of the work with crop improvement.

This must be so with the developments in breeding techniques and the demand for attention to more technical problems. There is little doubt that breeding work must direct more of its energies to the many pathological problems involved in resistance to fungi, viruses and insects, while even deficiency diseases may need to be included sooner than later. Pathological resistance combined with improved quality of the plant product are the two obvious means of crop improvement without upsetting agricultural systems of farming, or levels of productivity, while consumer requirements, whether of industry, various processing interests, or human and animal nutrition, have similar agricultural implications. There is no lack of urgent work to do, or of problems to be tackled, and the Institute looks forward to the second chapter in its history with great enthusiasm for the job, but with regret in its parting from the School of Agriculture.

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AGRICULTURAL ECONOMICS

Changes in the Economic Organisation of Agriculture. A Comparative Study of Conditions in the Eastern Counties of England between an Identical Sample of Farms in 1946-7 with Summaries of Unpublished Reports for the Years 1943-44, 1944-45, 1945-46.

Fm Econ. Br. Rep. No. 31. 1948. Pp. 40, Price 5s.

The 390 farms in this investigation are drawn from ten types of farming areas and in each of these net returns in 1947 were lower than in the previous year. Moreover, in half the districts they were insufficient to remunerate the farmers for their own work and provide 4 per cent. interest on the farm capital. Overall, the average profit surplus amounted to 5s. 1d. per acre in 1947 compared with £3 3s. 10d. per acre in 1946. Central Norfolk, Hertfordshire and Central Suffolk were the most heavily affected.

The disappointing returns in 1947 were mainly due to very low crop yields following an exceptionally severe winter, a late spring and an acute summer drought. Redeeming features were fine weather at harvest and good crops of clover seed which formed a vital source of income on many farms.

In the Isle of Ely, broken banks in the spring of 1947 temporarily devastated large areas but the fenland farms in the sample suffered little damage and in consequence the fall in profits was less than expected.

Overall Gross Income fell by 5 per cent. mainly as a result of lower crop yields, falls occurring in all districts except the Isle of Ely and South Essex. Although the overall income from livestock rose by some 10 per cent. between the two years, that from crops fell by about 14 per cent. and was particularly severe in Central Norfolk and in Hertfordshire.

Overall Gross Charges in 1947 were 8 per cent. greater than in 1946, and affected all districts except Central Suffolk where they fell by 5 per cent. This may have been due to enforced reduction in expenditure following a bad year in 1946.

Labour, which is the largest single item of expenditure, amounted in 1947 to 39 per cent. of total Gross Charges compared with 38 per cent. in 1946. Minimum wages rates rose by approximately 12 per cent. between the two years and were largely responsible for the rise of Gross Charges although increased expenditure on repairs and renewals of implements in all districts were contributory causes.

It is impossible to assess separately the changes due to shifts in (a) commodity prices, (b) costs and (c) quantities between the two years but it is evident that Gross Incomes fell owing to the low yields of crops while the rise in Gross Charges was not accompanied by any substantial quantitative change. As a result the volume of output per manual worker fell by nearly 20 per cent.

Land Ownership in the Eastern Counties, 1941. A Study of the Distribution of Estates and the Standard of their Equipment.

Fm Econ. Br. Rep. No. 30. 1947. Pp. 32. Price 6s.

This *Report* which deals with certain aspects of land ownership in the Eastern Counties¹ was prepared from data available in the 1941 National Farm Survey. It falls into two main sections, the first dealing with the numbers, types, and distribution of land-owners, the second with the quality and condition of their estates.

In 1941, by far the greater proportion of agricultural land in the ten counties was owned by private persons; only about one-tenth being owned by public companies, etc. Of the total area 28 per cent. was occupied by estates of over 2,000 acres. A comparison with roughly comparable statistics for six counties in 1873 showed that since then large estates had declined by about one-third, both in numbers and acreage. Those that remained were found to be mainly situated on the poorer soils, and particularly in the Norfolk Breck.

Despite the fact that the land in large estates was mainly let, nearly 43 per cent. of the total area was in owner-occupation. This is in marked contrast to the estimated 20 per cent. during the period 1887-1922.

The highest standard of estate equipment was maintained by the Public and Educational bodies with owner-occupied estates a close second. In the latter group, the quality of equipment increased with the size of estate, the largest estates showing an even higher standard than on properties belonging to the Public and Educational bodies. Equipment on estates let by private owners did not show any size-group variation and was distinctly poorer than in the other two groups. Other types of ownership were not sufficiently numerous to form a sample for investigation.

Thirty per cent. of all farms had two or more landlords, (including the owner-occupied) and, as might be expected, farm lay-out deteriorated considerably as the number of owners increased. Farms on large estates were not noticeably better arranged than those on small estates, although the opportunity for re-allocating fields must have been very much greater.

The presence or absence of a piped water supply appeared to depend mainly on whether mains were available in the district. Electricity was more frequently found on owner-occupied than on rented farms. Rent per acre decreased as the size of the farm increased. The better standard of estate equipment of the Public and Educational bodies was reflected in their rents, which were distinctly higher than those of land rented from private landowners.

Economics of Pig Production. Report. 1945-47.

Fm Econ. Br. Fmrs' Bull. No. 11. 1948. Pp. 14. Price 2s.

An analysis of the factors affecting the costs of pig production in fourteen herds in the Eastern Counties from October 1945 to September 1947.

¹ Cambridge, Bedford, Essex, Hertford, Holland (Lincs.), Huntingdon, Norfolk, Soke of Peterborough, and East and West Suffolk.

An Investigation into the Costs of Wheat Growing in 1946.¹

Fm Econ. Br. Mimeog. Rep. No. 33. 1947.

A Survey of the Cost of Producing Sugar Beet in Three Districts in the Eastern Counties, 1946.¹

Fm Econ. Br. Mimeog. Rep. No. 34. 1948.

STURROCK, F.

Farm Accounting and Management.

Pp. xii + 211. Pitman, London, 1948. 16s.

AGRICULTURAL ZOOLOGY (including Entomology)

933* JONES, D. P. & JONES, F. G. W.

Wireworms and the Sugar Beet Crop : Field Trials and Observations.

Ann. Appl. Biol. 1947, **34**, 562-74.

Observations on wireworms in the sugar-beet crop during 1937-40 indicated the importance of alternative food, such as buried turf, excess seedlings and interdrilled wheat in determining the degree of injury to the crop.

In 1938, out of thirty-six recorded fields growing sugar beet after ploughed-up grass only one suffered severe wireworm damage. Six of these fields were selected for resowing with sugar beet in 1939, and all suffered moderate or severe attacks. Several other fields in their first year from grass showed only slight damage. These observations were supported by an analysis of the Norfolk War Agricultural Committee crop records for 1940.

Seven trials were carried out in 1939 to determine the effect of increasing the seed rate from normal (about 14-16 lb. acre) to 17-25 lb., and of interdrilling with wheat. In three trials, increasing the seed rate gave significantly higher plant populations before singling. It gave significant increase after singling in one out of two trials. However, in the one trial harvested the increase in 'washed beet' was only 7.6% and 'total sugar' 15%. Interdrilling with wheat at 40-70 lb./acre gave significant increases in the plant population before singling in three out of five trials, and after singling in three out of four trials. Increased plant populations both before and after singling were obtained in two other trials with alternating treatments. Increased seed rate and interdrilled wheat together gave greatly improved plant populations before singling in each of two trials and after singling in the one trial where such an observation was possible.

ROSS, D. M., STAPLEY, J. H. & COCKBILL, G. F.

Wireworm Populations in Relation to Crop Production. V. Comparisons between Failing and Successful Plots.

Ann. Appl. Biol. 1948, **35**, 193-206.

It is well known that infestation is only one of a number of factors which determine the amount of wireworm damage occurring in a field. As an attempt to analyse the conditions under which crops fail from wireworms, thirteen fields showing both damaged and undamaged areas were studied. Data were collected on wireworm populations, chemical and mechanical composition of the soil, feeding reactions of the wireworms collected, agricultural history and treatment of the different plots and fields. In six only of the fields did the damaged areas coincide with areas of higher infestation. In the remainder, the failures occurred at low populations, and no marked differences in population could be detected between the failing and successful plots. The levels of population at which the failures occurred varied between wide limits in the different fields. Two of the edaphic factors investigated were associated consistently with the failing and successful plots; CaCO_3 was consistently higher and sand content consistently lower on the failing plots. Differences in these factors were particularly noticeable in those fields where differences in infestation were not detected. There is a suggestion from four of the fields that wireworm attack commonly follows sainfoin. None of the other factors showed significant relationships. Although the results suggest that differences in one or more of the factors, infestation, CaCO_3 and sand, are associated with differences in wireworm damage within fields, the differences between the fields cannot be explained so simply. Evidently, other factors, relatively uniform within single fields but varying from field to field, also influence the amount of wireworm damage. Consideration of the results in relation to wireworm and plant populations brings out the need for greater attention to the role of wireworm activity and the environmental factors which influence it. The importance of reliable methods for predicting wireworm damage to any methods of control is stressed.

939* WRIGHT, D. W. & GEERING, Q. A.

The Biology and Control of the Pea Moth (*Laspeyresia nigricana* Steph.).

Bull. Ent. Res. 1948, **39**, 57-84.

In an investigation on the biology of the pea moth observations were made on the following: emergence period of the moths, behaviour of the moths in the field, preoviposition period, the egg stage, the larva, larvae populations in the field, overwintering populations of larvae, behaviour of larvae in the soil, effect of soil temperature on overwintering larvae, the pupal stage. Experimental evidence is produced to show that in Great Britain the moth is incapable of passing through more than one generation in a year. Three hymenopterous parasites are recorded, *Ascogaster quadridentatus* Wes.: *Glypta haesitator* Gr. and *Hemiteles ridibundus* Gr.

¹ Continuation of the War Series Reports. Obtainable from the Farm Economics Branch.

The results of two variety trials are given and show that varietal differences in susceptibility to pea moth attack do occur, and are associated chiefly with differences in time of flowering and rate of maturation and with the degree of plant cover. Critical sowing dates resulting in maximum attack vary for different varieties and also with the season. Other methods of cultural control are also outlined.

Field and small scale trials showed that DDT emulsions and suspensions give very satisfactory control. Careful timing is necessary to assure that the insecticide is applied before egg hatching commences.

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AGRICULTURE

BELL, G. D. H.

Cultivated Plants of the Farm.

Pp. xii+199. 36 illus. Camb. U.P., 1948. 15s.

MANSFIELD, W. S.

The University Farm.

Golden Sheaf. C.U.A.S. 1948, **7**, (1), 5-7.

WOODMAN, H. E.

Grass Conversion.

Agriculture : J. Minist. Agric. 1948, **54**, 501-4.

ANIMAL BREEDING AND GENETICS

944* DAVISON, W. F.

The Control of Ovulation in the Mare with Reference to Insemination with Stored Sperm.

J. Agric. Sci. 1947, **37**, 287-90.

In pony mares during oestrus in which a follicle was considered to be sufficiently ripe (thin walled) the intravenous injection of 500 i.u. pregnancy urine extract induced ovulation in nineteen out of twenty-three mares between 24 and 48 hr., in three cases within 24 hr., and in one case between the fourth and fifth days.

Dialysed egg yolk as a medium for storage of horse sperm for 24 hr. was shown to give satisfactory results when ovulation was controlled by the above method, so that it occurs within 24 hr. after insemination. Nine single inseminations during one oestrus resulted in five pregnancies.

The number of spermatozoa required for successful insemination is discussed.

Means of detecting a sufficiently ripe follicle before injection with pregnancy urine extract are described.

It is shown that the duration of oestrus is shortened as the result of pregnancy urine injections.

Data is given concerning the time which elapses between ovulation and the cessation of oestrus.

953* DUDLEY, F. J. & PEASE, M. S.

Experiments in Top-Crossing Poultry.

Off. Rep. 8th World's Poult. Congr. 1948, **1**, 285-290.

An account is given of an experiment carried out at Reaseheath in top-crossing white leghorns over eight years. The object of the work was to find out whether on an average, top-crossing is a better method of breeding utility poultry than the accepted commercial way of outbreeding. The breeding unit consisted of a highly inbred male mated to two outbred females, and a selected outbred pedigree male mated to two sisters of the females mated to the inbred male : 67 such units were tested.

The percentage of chicks hatched from the eggs of the top-cross matings was on the whole slightly lower than that for the out-cross matings ; the top-cross pullet progeny had a smaller percentage loss during rearing, but at the end of the rearing were significantly lighter in weight. No important difference was shown between the two types of progeny in the age at which they began to lay, the average number and weight of eggs laid, or in the percentage mortality. The inbred males, therefore, performed nearly as well as the carefully bred and selected outbred males, but no better.

PEASE, M. S.

Cream Legbars.

Autosex. Annu. 1948, pp. 6-7.

An account is given of the making of a new autosexing breed, which lays a blue egg and has "cream" plumage. "Cream" is due to a recessive gene which dilutes the ordinary gold plumage to such an extent that the bird appears to be silver, though genetically it behaves as a gold. Cream was found to be present in the Reaseheath White Leghorns and also in Grey Bresse in Black Jersey Giants.

952* PEASE, M. S.

Inbreeding of Poultry Live Stock Improvement.

Off. Rep. 8th World's Poult. Congr. 1948, **1**, 33-42.

The spectacular improvement of maize in America by the use of inbred lines has focused attention on the application of these methods to the problems of poultry live stock improvement. An account is given of five inbred lines of white leghorns established at Reaseheath, Cheshire ; these five lines have been crossed amongst themselves in every combination. One pair of lines has given incross birds with egg yields consistently higher than those of the corresponding control outbred birds. Conversely, another pair has given consistently poorer egg yields than the control, in both cases over the three years for which there are records. Although the five Reaseheath lines have been inbred now for many generations—the birds show little approach to uniformity in the character measured. A suggestion for the genetics of this unexpected result is put forward.

OTHER PAPERS

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HAMMOND, J. **Problems of Dairy Cattle Improvement.** *Brit. Cattle Breed. Club Digest.* 1948, **3**, 40.

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PEASE, M. S. **Cambridge Autosexing Breeds.** *Autosex. Annu.* 1948, 8-17.

PEASE, M. S. **Inbreeding and Crossbreeding.** *Brit. Cattle Breed. Club Digest.* 1948, **3**, 66.

PEASE, M. S. **Mendelian Inheritance.** *Brit. Cattle Breed. Club Digest.* 1948, **3**, 47.

PEASE, M. S. **Multiple Factor Inheritance.** *Brit. Cattle Breed. Club Digest.* 1948, **3**, 50.

WALTON, A. **Life and Size of Herds in Relation to Selection.** *Brit. Cattle Breed. Club Digest.* 1948, **3**, 85.

YEATES, N. Y. M. **Modification of Breeding Season in the Sheep.** *Brit. Sci. News.* 1947, **1** (4), 16-8.

ANIMAL NUTRITION

938* HALNAN, E. T.

British Needs and Resources of Calories, Protein and Calcium. Home Production of Eggs.

Brit. J. Nutrit. 1947, **1**, 299-300.

It is estimated, from available data, that home production of eggs could be expanded to supply 161 eggs per head of population provided the feeding stuffs were made available. It is calculated that the release of 10% of home produced barley and wheat for poultry feeding, plus the extra wheat offals made available by reducing the flour extraction rate to 70% would supply the extra feeding stuffs required.

HALNAN, E. T.

Poultry as Converters of Vegetable Food for Human Use.

Chem. & Indus. 1948, No. 12. 189.

The limits to which poultry can make use of vegetable and root foods in their diets are briefly dealt with. The indicated limits of food saving for various feeding stuffs were *grass*, fowls, 5-10%, turkeys 16%, ducks, 18%, geese 100% ; *household waste*, fowls 35%, *potatoes*, fowls, 50%.

HALNAN, E. T.

The Role of Urea and Ammonium Compounds as Protein Substitutes in Poultry Nutrition.

Off. Rep. 8th World's Poult. Congr. 1948, **1**, 233-6.

Experiments are described designed to ascertain the potential value of urea and ammonium compounds as protein substitutes in poultry nutrition. Whereas ammonium salts of inorganic acids appear to be excreted unchanged, both urea and ammonium salts of organic acids are rapidly converted to uric acid and excreted as such. The rapidity with which this conversion takes place strongly supports the view that urea and ammonium compounds are incapable of acting as protein substitutes in poultry nutrition. This view is further supported by the negative nature of feeding trials, in which urea proved useless as a partial or complete substitute for protein in chick diets or in layer's mashes.

HALNAN, E. T.

Scientific Principles of Poultry Feeding. 6th Ed.

Bull. 7. Minist. Agric. (H.M.S.O., 1948. 2s.)

921* HAMMOND, J.

Nutrition and Health in Animals.

Health Educ. J. Oct. 1947.

A popular account of the effects of nutrition during pregnancy on birth weight and milk production of ewes and of the plane of nutrition during the growing period on the growth and development of pigs.

935* HUTCHINSON, J. C. D.

Nutrition of Domestic Rabbits. 1. The Effect of Nutrition on the Carcass Composition of the Rabbit.

Brit. J. Nutrit. 1948, **1**, 219-30.

Two groups of domestic rabbits were fed on a stock ration till weaning and thereafter for 7 weeks on a ration of weeds and of potatoes and hay, respectively. Some of the potato-fed group received a supplement of casein.

Growth rates and the shape of the growth curves throughout the life of the two groups were approximately the same. Growth during the 7 weeks' period of the feeding experiment was about three-quarters of the maximum.

The average dressed-carcass weights, killing out percentage and relative weights of joints of meat of the two groups were approximately the same.

The carcasses of the potato-fed group contained twice as much total edible chemical fat as those of the weed-fed group, and four times as much chemical fat around the kidney and over the shoulders and pubic region.

During the 7 weeks' feeding experiment the potato-fed group laid down seven times as much edible chemical fat as the weed-fed group. The animals in this group laid down a fair amount of fat round the kidney and over the shoulders and pubic region while the weed-fed group laid down none at all in these parts.

The edible protein content of the carcasses of the two groups was approximately the same.

It is concluded that the fat content, and therefore energy value of rabbit meat for human nutrition cannot be assessed from the live weight or dressed carcass weight, nor from a knowledge of the rate of growth or shape of growth curve, because fat deposition is profoundly influenced by the qualitative nature of the ration.

936* HUTCHINSON, J. C. B.

Nutrition of Domestic Rabbits. 2. The Efficiency of Rabbit-meat Production from Weeds, Fed alone and with Cooked Potatoes.

Brit. J. Nutrit. 1948, **1**, 231-44.

The efficiency of fattening weaned domestic rabbits on weeds only (mainly sow thistles) and on weeds with a limited amount of cooked potatoes has been investigated.

With rabbits increases in live weight, edible protein, fat, gross energy, energy available for human nutrition, and conversion of food into rabbit meat were measured; for man the cost in time and energy of collecting weeds was determined.

Growth and the production of animal protein were for the weed-fed group of rabbits 75 and 73.2%, and for the group fed weeds and potatoes 91 and 87.4%, of the values for a control group of rabbits on a stock ration.

The production by the group fed on weeds alone of fat, gross energy and available energy was 8.8, 37.4 and 32.5% respectively, of the production by the control group. The figures for the group fed weeds and potatoes were 76.2, 81.0 and 80.0%.

The weed-fed group converted 100 g. of dry matter of food into 2.24 g. edible protein, 0.26 g. fat, 14.4 Cal. gross energy and 10.8 Cal. available energy. The conversion figures for the group fed weeds and potatoes were 2.52 g., 1.61 g., 29.6 Cal. and 25.2 Cal. and for the control group 2.98 g., 2.25 g., 38.2 Cal. and 33.1 Cal. respectively.

From 100 Cal. available energy fed as potato to the group on weeds and potatoes 20.5 Cal. available energy were obtained as rabbit meat.

It took 30 man-hours labour to collect weeds to provide available energy (2400 Cal.) for 1 man for 1 day by converting weeds alone into rabbit meat. The corresponding figure for the group fed weeds and potatoes was 9 hr. 36 min. The provision of 1 day's supply of animal protein (32.5 g.) took 2 hr. by feeding weeds alone and 1 hr. 19 min. by feeding weeds and potatoes.

If, in addition, the energy cost to man of collecting weeds was taken into account, there was a net loss of energy in feeding with weeds alone, and the net gain, though positive, was much reduced when potatoes were included in the ration.

It is concluded that rabbits fed on weeds or weeds and potatoes are very inefficient producers of available energy for human nutrition but that animal protein is produced more efficiently than available energy.

The value of the operation of producing rabbit meat from weeds depends on the relative value to man of available energy and of animal protein with its associated vitamins in times of food scarcity.

HUTCHINSON, J. C. B.

The Use of "Bactoflavin" as a Vitamin Supplement in the Rations of Growing Chicks.

Off. Rep. 8th World's Poult. Congr. 1948, **1**, 120-4.

The value of "bactoflavin", a byproduct in the manufacture of acetone by the fermentation process, has been tested as a vitamin supplement in the rations of growing chicks. It was found to prevent "curled toe paralysis". Growth with 5% "bactoflavin" in the ration was not quite so rapid as with 5% dried brewer's yeast but rather better than with 5% dried skimmed milk. "Bactoflavin" gave some protection against gizzard erosion.

WOODMAN, H. E.

Rations for Livestock. 11th ed.

Bull. 48, *Minist. Agric.* (H.M.S.O., London, 1948. 2s. 6d.)

925* WOODMAN, H. E. & EVANS, R. E.

The Chemical Composition and Nutritive Value of Ryegrass-seed Meal, Clover-seed Meal, Lucerne-seed Meal and Sainfoin-seed Meal.

J. Agric. Sci. 1947, **37**, 311-5.

The wartime expansion in the home production of grass, clover and other seeds raised the question of the value of such seeds as food for livestock, since during the later years of the war, surpluses that had been discarded on account of low germination or other causes were being sold to compound manufacturers for inclusion in cattle foods. During 1944, the writers made determinations of the digestibility and starch equivalents of the following seeds: rye-grass (a mixture of Italian and Perennial), red clover, lucerne and unmilled sainfoin. All the samples were reduced to a fine meal before being submitted to test in the digestion trials.

Apart from its lower content of digestible ether extract, ryegrass-seed meal resembles oats in respect of chemical composition, digestibility and starch equivalent. It is a carbohydrate concentrate, containing, on the dry matter basis, 69.4% of starch equivalent, including 7.3% of digestible protein.

The meals from red clover seed and lucerne seed show a close resemblance to linseed cake in chemical composition, digestible composition and starch equivalent. They are to be classed with the protein concentrates, in which respect they are sharply distinguished from ryegrass-seed meal. Both these leguminous seeds are rich in digestible ether extract, a characteristic that differentiates them from beans, the commonly fed leguminous grain.

Un-milled sainfoin seed yields a meal with a somewhat lower content of digestible protein and starch equivalent than red clover-seed meal or lucerne-seed meal. Nevertheless, it contains, on the dry matter basis, 25.8% of digestible crude protein and 6.1% of digestible oil, and has a starch equivalent about equal to that of crushed oats or ryegrass seed meal. There can be little doubt that grinding of the de-podded sainfoin seed would yield a meal equal to that from red clover seed or lucerne seed in digestible composition and starch equivalent.

With the exception of un-milled sainfoin seed, all the seeds submitted to analysis are deficient in lime and chlorine, but contain a satisfactory percentage of phosphoric acid. Removal of the pods before grinding the sainfoin seed reduces the lime content of the meal from about 1 to 0.25%. All the seeds were found to be free from cyanogenetic glucosides.

It is concluded that the grass, clover, lucerne and sainfoin seed which might be discarded for various reasons by the seed trade should form useful additions to the list of concentrates available for farm animals. Their feeding value will naturally be influenced to some extent by the proportion of 'cleanings' that they contain. The need for the fine grinding of such seed before feeding is responsible for the rather dusty nature of the resultant meals, and for this reason it is advisable that they should be fed to livestock in admixture with other concentrates or used for inclusion in compound foods.

942* WOODMAN, H. E. & EVANS, R. E.

The Composition and Nutritive Value, when Fed to Pigs, of Whale-meat Meal, White-fish Meal, Feeding-meat Meal, Extracted Decorticated Ground-nut Meal, Bean Meal and Dried Yeast.

J. Agric. Sci. 1948, **38**, 200-6.

The writers are at present engaged in carrying out investigations into the relative supplemental values of the proteins in certain feeding stuffs that are commonly used to correct the protein deficiencies, in respect both of amount and quality, of the cereal grains and their by-products. It was necessary to obtain information about the digestibility of these protein supplements and their content of digestible protein and "total digestible nutrients", since available British data in this connection relate, for the most part, to the digestibility of these feeding stuffs when they form part of the rations of sheep and cattle.

An outline is given of the modern Fauth process of preparing whale-meat meal rich in protein and low in moisture, fat and ash content. The consignment of whale-meat meal examined contained only 5.58% of moisture, and the crude protein content amounted to as much as 87.8%, compared with 58.3 and 65.9%, respectively, in white-fish meal and feeding-meat meal. Moreover, the percentage of non-protein nitrogenous material in the whale-meat meal was only 5.2% as compared with 10.8% in white-fish meal and 15.9% in feeding-meat meal, this being a significant distinction in relation to pig nutrition, since the "amide fraction" has little or no value for the synthesis of protein in the body of the growing pig. The whale-meat meal manufactured by the above process is from muscular tissue unmixing with bone, so that the percentage of ash is low and a pronounced deficiency is noted both in lime and chlorine. In this respect whale-meat meal is sharply distinguished from both white-fish meal and feeding-meat meal.

In discussing the results of the digestion trials, reference is made to an unusual finding in the tests on whale-meat meal, since the addition of this fibre-free food to the basal ration was found to depress the digestibility of the crude fibre from +15.7 to -9.3%. It was shown that the whale-meat meal contained a small amount of nitrogenous matter which remained undissolved after the acid and alkaline treatments of the fibre estimation. This material, of a gristly character, also escaped digestion during the passage of the food

through the alimentary tract and was excreted in the faeces. Owing to its insolubility in the fibre reagents, it was estimated as part of the indigestible fibre in the analysis of the composite samples of the faeces.

The digestion coefficients of the main constituent, namely, the crude protein, ranged from 95.4% for white-fish meal to 80.4% for bean meal. The digestibility of the protein in whale-meat meal (87.6%) compares very closely with the corresponding value for extracted feeding-meat meal (87.9%). It is also of particular interest to note that the protein in extracted decorticated ground-nut meal, a supplement of plant origin, is as highly digestible as the protein in the concentrates of animal origin. This is also true of the different class of protein in dried yeast. The digestion coefficient for pigs of the yeast protein (89.4%) is of the same order as the value obtained in digestion trials with sheep.

Judged on the basis of the digestion coefficients of the total organic matter in the different supplements, there is little difference, in respect of digestibility, between whale-meat meal, white-fish meal, feeding-meat meal, extracted decorticated ground-nut meal and dried yeast. In all these cases the digestion coefficient of the organic matter lies in the neighbourhood of 90%, a sufficient indication of the high digestibility of these feeding stuffs when included in the rations of bacon pigs. The value falls to 83.9% in the case of extracted feeding-meat meal, a depression that is probably to be ascribed to an effect of the hot solvent during the extraction of the fat, and still further to 78.7% in the case of bean meal.

On account of the varying mineral content of the several protein supplements, however, there is a considerable variation in the figure for "total digestible nutrients". In consequence of its low ash content, whale-meat meal is distinguished by its relatively high content of "total digestible nutrients" (90.6% on the basis of dry matter), although in this respect, the ordinary feeding-meat meal, because of its high fat content, is of comparable value. The corresponding figure for white-fish meal is 67.3%. In other words, whale-meat meal is to be regarded solely as a protein supplement when used in the rations of bacon pigs, whereas white-fish meal forms a source of both protein and minerals. Both dried yeast and bean meal, on account of their low content of minerals are very distinctly richer in "total digestible nutrients" than white-fish meal.

929* WOODMAN, H. E. & EVANS, R. E.

The Nutrition of the Bacon Pig. XII. The Value of Dried Grass Meal for Growing and Fattening Pigs.

J. Agric. Sci. 1948, 38, 51-63.

It has been shown in a previous communication that the meal-replacement value of young grass in actual pig-feeding practice is considerably poorer than would be anticipated from a consideration of its content of 'total digestible nutrients' as determined by means of pig digestion trials. This is because the figure for 'total digestible nutrients' takes no account of the energy expended by the pig in consuming and masticating its food. Although this wastage of energy does not represent a serious loss in relation to the rate of live-weight increase in the case of ordinary pig meals fed in the form of a thick slop, it becomes of considerable significance when grass forms a major component of the diet, on account of the bulkiness of the grass and its unfavourable physical texture from the standpoint of consumption by pigs.

It seemed justifiable to assume that if grass could be included in the pig's diet in such a form as would reduce the muscular energy involved in its consumption to the level associated with the consumption of an ordinary pig meal, its meal-replacing value would be such as could be predicted from its content of 'total digestible nutrients'. Viewed from this standpoint, there seemed to be a considerable advantage in supplying the grass in the form of dried grass meal, since by this means the disadvantages of bulkiness and unfavourable physical texture would, to a large extent, be overcome. Moreover, by incorporating the grass meal with the other meals and feeding the whole ration in the form of a thick slop, the expenditure of muscular energy in consumption and mastication should be little greater than with an ordinary mixture of meals. It should in this way be possible to obtain the most favourable estimate of the nutritive value of young grass for pigs in terms of meal.

With this objective in view, a farm-scale feeding trial has been carried out in which grass meal, of known digestible composition, has formed approximately one-third of the total ration of bacon pigs. A preliminary digestion trial with pigs showed that the grass meal obtained for the feeding test contained, on the basis of dry matter, 64.95% of 'total digestible nutrients', and from this it was deduced that, on an equal moisture basis, 30 parts of the grass meal contained as much 'total digestible nutrients' as a mixture of 25.5 parts of fine bran and 4.5 parts of coarse bran. Accordingly, the diet submitted to test was derived from the control diet by replacing 25.5 parts of fine bran and 4.5 parts of coarse bran by 30 parts of grass meal, the control diet being made up as follows: 42% of barley meal, 40.5% of fine bran, 4.5% of coarse bran, 3% of grass meal and 10% of white fish meal.

Ten pigs were kept on the control diet (treatment A) and two duplicate lots of ten pigs on the diet containing 33% of grass meal (treatment B1 and B2). All the pigs were fed individually. Since the animals on all three treatments were subsisting on rations containing the same percentage of 'total digestive nutrients', it was to be expected that the partial replacement of the wheatfeeds by grass meal would occasion no depression of the rate of live-weight increase or the efficiency of food conversion provided (1) that appetite and food consumption did not suffer as a consequence of such factors as bulk and palatability, and (2) that the energy expended by the pigs in dealing with the ration containing 33% of grass meal was comparable in magnitude with that used up in the consumption of the all-meal control ration.

The pigs on the B treatment were brought on to the diet containing 33% of grass meal at 45-50 lb. live weight. They found the ration quite palatable when fed in the form of a thick slop and needed no more than about 5 min. longer than the control pigs to clean up their troughs. The mean result for the pigs on the three feeding treatments showed remarkable close agreement over the period from 50 to 150 lb. live weight, both

in respect of the rate of live-weight increase and the requirement of food per lb. of live-weight gain. The data for this period leave no doubt as to the ability of grass meal to exert a productive effect in the rations of bacon pigs such as would be predicted from a knowledge of its content of 'total digestible nutrients' as determined by pig digestion trials.

From 150 to 200 lb. live weight, the pigs on the diet containing 33% of grass meal were somewhat less thrifty than the control animals, as evidenced by a mean live-weight increase of 1.30 lb. per day, with a food requirement of 4.95 lb. per lb. of live-weight gain, compared with 1.40 and 4.60 lb., respectively, for the pigs on the control treatment. This slightly poorer progress was due partly to the increasing bulkiness of the ration containing the grass meal, which made necessary a reduction on a number of days of the food allowances of some of the B pigs, and partly to a marked increase in the amount of energy expended by these pigs at feeding times. Over this period, they required about 10 min. longer than the control pigs to clean up their troughs, and the magnitude of the 'activity factor' underwent a noticeable increase.

Over the entire experiment from 50 to 200 lb. live weight, the differences between the three sets of results were of a minor order and did not reach statistical significance. For reasons explained in the text, the results for the pigs on treatment B2 afforded the better basis for comparison, and during the experiment as a whole, these pigs averaged 1.27 lb. of live-weight increase per day, with a mean food requirement of 3.95 lb. per lb. of live-weight gain, compared with 1.28 and 3.85 lb., respectively, for the control animals.

The complete results, therefore, lead to the conclusion that when grass, in the form of dried grass meal, is included in *appropriate amount*, in the diets of bacon pigs, and the rations are fed as a thick slop with water, it is able to contribute its full value, as computed from its content of 'total digestible nutrients', towards maintenance and live-weight increase. The grass meal should not form more than 33% of the total ration, and beyond 150 lb. live weight it might with advantage be included at a somewhat lower level, say, 20-25%. Under such conditions of feeding, bacon pigs should be able to consume their full rations with an expenditure of energy little greater than that associated with the consumption of rations composed of ordinary pig meals. Attempts to feed grass meal in higher amounts will result in the rations becoming too bulky, and, as a consequence, the level of food consumption will go down, or the expenditure of energy by the pigs in their efforts to deal with the full rations, will be increased significantly. In either case, the consequence will be that the rate of live-weight increase will fall below the anticipated value.

It may be concluded, therefore, that under the most favourable conditions of feeding (i.e. as a dried meal), the food material in grass has a value for pigs comparable with that of fine bran (85% extraction). When fed in the fresh condition, however, or when secured in the process of grazing, grass has a much lower value for pigs than is represented by this finding. For ruminants, the grass meal used in the present investigation would have had the starch equivalent about equal to that of oats.

From the results of the post-slaughter gradings and measurements, it was found that the pigs which had received the ration containing 33% of grass meal had a slightly, though significantly, lower carcass percentage than the control animals, and a significantly thinner back fat and belly streak. The leaner character of these pigs was attributed, in the main, to their greater expenditure of energy on muscular activity during the later stages of the fattening period. Despite this, however, the carcasses were deemed satisfactory from the standpoint of conversion into bacon. It was observed that the fat in the carcasses of some of the twenty pigs on treatments B1 and B2 had a faint yellow colour, resulting from the storage of carotene from the grass meal in the ration.

947* WOODMAN, H. E. & EVANS, R. E.

Nutrition of the Bacon Pig. XIII. The Minimum Level of Protein Intake Consistent with the Maximum Rate of Growth (Part V).

J. Agric. Sci. 1948, **38**, 354-65.

The metabolism trials described in the present communications were undertaken with the object of testing the conclusions arrived at in farm-scale feeding trials, designed in accordance with the requirements of the modern statistical lay-out, respecting the minimum protein supply needed to support the maximum rate of growth in bacon pigs.

Two feeding treatments were submitted to test. The first, referred to as the standard protein treatment, contained 10% of white-fish meal up to 150 lb. live weight, at which stage the fish meal was omitted and replaced as a source of protein, by 5% of extracted, decorticated ground-nut meal; whilst the second, described as the low-protein treatment, contained only 7% of white-fish meal up to 90 lb. live weight and no protein-rich supplement thereafter. The meal supply was adjusted throughout the experiment in accordance with the live weights of the pigs. Precautions were taken to ensure that the two treatments were equal, as nearly as possible, in respect of their content of total digestible nutrients at all stages of the trials, and differences in mineral supply were rectified by the use of suitable amounts of a mineral supplement containing 3 parts by weight of chalk and 1 part of common salt. Systematic determinations of the nitrogen, lime, phosphoric acid and chlorine balances were carried out on the pigs subsisting on the two feeding treatments over a range of live weight from 25 to 220 lb.

The results of the protein metabolism experiments demonstrate that the inclusion of 10% of white-fish meal in the rations of bacon pigs from weaning to 150 lb. live weight is unnecessarily generous, particularly beyond 90 lb. live weight, and that a diet composed substantially of barley meal and middlings (or fine bran) together with a small allowance of grass meal or lucerne meal, and containing no more than 7% of white-fish meal up to 90-100 lb., followed by the complete omission of the high-protein supplement at this live weight, enables body protein to be deposited at a rate equal to that displayed by pigs on rations made up in accordance

with the conventional standards in respect of fish-meal content. The data obtained from the nitrogen balance trials shows how the reduced supply of dietary protein is subject to a more efficient utilization in the body of the animal. Beyond the live weight of 90–100 lb., the mixture of barley meal and middlings (or fine bran), supplemented with a little artificially dried green food, is able to supply all the digestible protein required at this stage for the maximum rate of retention of protein. The results afford a satisfactory general confirmation of the conclusions arrived at on the basis of the findings from the statistically designed, farm-scale trials, namely, that the foregoing lowering of the plane of protein supply gives rise to no depression of the rate of live-weight increase or the efficiency of food conversion.

The results in the case of the mineral balances disclosed the fact that the pigs on the low-protein diet, over a period when they were deriving their phosphoric acid exclusively from barley meal, fine bran and a small allowance of grass meal, and their lime mainly from the chalk-salt mineral supplement, were able to retain P_2O_5 at an average rate of 7.1 g./day, the simultaneous storage of CaO proceeding at the comparable rate of 7.3 g./day. The results support the belief that pigs are able to make good use of the phosphorus in barley meal and fine bran, despite the fact that much of this element in these cereal foods is present as phytic acid. Adjustment of the lime content of the cereal part of the ration by the addition of a suitable amount of chalk made possible a satisfactory rate of retention of both CaO and P_2O_5 .

The continuously increasing chlorine intake in the successive periods had mainly the effect of increasing the chlorine output in the urine, but the actual balances, though small and somewhat irregular from period to period, were positive in every case, showing that when bacon pigs are kept on rations, such as are used in good feeding practice, no fear need be entertained of any diminution of the reserves of chloride in the body.

ANIMAL PHYSIOLOGY

941* HAMMOND, J.

Endocrine Balance in Relation to Fertility and Sterility.

1st Int. Congr. Physiopath. Milan, 1948.

From a survey of the facts and experiments which have been made in this field it is concluded that the balance between the Follicle Stimulating Hormone and Lutealizing Hormone secretions of the anterior pituitary gland, and between the oestrogens and progesterones from the ovary, play an important part in regulating fertility and sterility in farm animals. This balance varies in different species so that some, such as the horse, are more prone to deficiencies in L.H. and progesterone than others, such as cattle, which are more prone to deficiencies in F.S.H. and oestrogen. The effectiveness of treatment with hormones in different species varies in the same way, L.H. and progesterones are most effective with horses, and F.S.H. and oestrogens with cattle. This applies also to treatment for specific uterine infections such as trichomonas infection in cows; and possibilities for abnormalities, such as physiological abortion during pregnancy in mares. The mechanism of multiple ovulations and the development, or failure of development, of the resulting fertilized ova also probably depend on this balance.

WALTON, A.

Respiratory Activity of Spermatozoa in Egg Yolk and in Its Separate Constituents.

1st Int. Congr. Physiopath. Milan, 1948. Summary from *Zoot. e Vet.* 1948, 3(6), 3–4.

The value of egg-yolk as a medium for the preservation of the mammalian spermatozoon was discovered by Phillips and Lardy (1940) by empirical trials of a number of animal tissue extracts. Except for the work of Lasley and Mayer (1946) who isolated from the yolk a substance which protected the spermatozoon from "temperature shock" as assessed by the method of differential staining, no systematic attempt has been made to isolate the constituents of the yolk responsible for its preservative function or determine the mode of their investigation since not only might it lead to the discovery of improved media for sperm preservation, but might add to our knowledge of the interaction between sperm and ovum in the process of fertilisation.

The general plan of the investigation has been to separate by physical or chemical means, the various constituents of the egg-yolk and then determine the effect of each constituent on various physiological and metabolic reactions of the spermatozoon.

As a criteria of respiratory activity we have relied mainly on O_2 uptake in the Barcroft Dixon differential manometer, and measurement of fructolysis by the colorimetric method of Mann (1948).

Motility has been assessed subjectively.

OTHER PAPERS

950* MARSHALL, F. H. A. Application of Sexual Physiology to Human Affairs. *Biol. & Human Affairs.* 1948, 13, 165–9.

922* HAMMOND, J. The Span of Life. *Proc. Roy. Soc. Med.* 1947, 40, 641–3.

WALTON, A. Physiology of the Dairy Cow. I. Ruminant. *Home Farm.* 1948, 15 (9), 14–5.

WALTON, A. Spermatogenesis and the Function of the Epididymis in Relation to Survival of Spermatozoa in vitro. *Conf. on Infertility. Family Planning Assoc.* London, 1947, 36–7.

ANIMAL PRODUCTION

GALPIN, N.

A Study of Wool Growth. II.

J. Agric. Sci. 1948, 38, 303–314.

By measurement of single fibres from tattooed squares the variation in hip region mean cross-sectional area, mean fibre length and area of skin covered by fibre substance in a small flock of Romney sheep has been

studied for a few years—see Part I. (*J. Agric. Sci.* **37**, 275). Under good growing conditions the area of skin covered by fibre is a constant percentage of the skin area for all sheep in all years. The number of fibres per unit area varies from sheep to sheep, and the mean cross-sectional area is inversely proportional to the number of fibres per unit area. The mean length/day is a constant for all sheep. When conditions are unfavourable the percentage of the skin area covered by fibre on a particular sheep falls below the good growing conditions percentage by an amount that is smaller the bigger the skin expansion ratio, but is greater the worse the season. The number of fibres per unit area for an adult sheep depends upon the number of fibres per unit area at 7 months, and its skin expansion after 7 months. The number of fibres at 7 months is about 0.75 times the month-old number per unit area, i.e. the bigger the skin expansion ratio the bigger the increase in the number of fibres in a defined area. The mean length/day grown under suboptimum conditions depends on the skin expansion ratio and the badness of the conditions. The number of active follicles appears to be smaller under suboptimum conditions.

946* HAMMOND, J.

Artificial Lactation and Its Uses.

Festsk. tel Prof. Per Tuff, Oslo, 1948, p. 134-46.

A discussion of some of the problems of milk production with a description of the method of induction of milk production by implantation of stilboestrol tablets in sterile heifers and cows.

937* HAMMOND, J.

Home Production of Meat.

Brit. J. Nutrit. 1948, **1**, 292-6.

A survey of British food needs and possible resources in meat production.

ROBINSON, P.

The Effect of Supermaintenance and Submaintenance Diets on Mature Border Leicester-Cheviot Ewes.

J. Agric. Sci. 1948, **38**, 345-53.

Ten fully grown Border Leicester-Cheviot ewes were divided into two groups of five; the heavier ones being about 150 lb. live weight, and the lighter ones about 70 lb. The former were placed on a low plane of nutrition, and the latter on a high plane. As the weights changed by successive amounts of 20 lb. animals were killed and dissected, and their organs and tissues weighed.

The decrease from 150 to 70 lb. live weight took 208 days, whereas the similar increase took only 80 days.

Except in certain cases, quoted below, the various parts of the body increased and decreased along similar development curves.

The magnitudes of the effects on the three main tissues were in the reverse order to their development. Bone showed no significant change; muscle showed a linear change; the fat showed a non-linear change, commencing slowly and then proceeding more rapidly in the supermaintenance series, but decreasing rapidly at first and then more slowly in the submaintenance series.

The muscle in all parts of the body increased and decreased at a steady rate, so that the proportion of muscle in the various joints remained approximately constant.

There was a close relation between the weight of blood and that of muscle of the animal. The blood increased in such a manner as to maintain an approximately constant ratio between these two quantities.

The measurement B (depth of 'eye' muscle) gave a good indication of the weight of muscle in the animal.

The liver of animals placed on the supermaintenance diet underwent a rapid increase in weight at first, but the rise became gradually slower with the organ tending to a ceiling value. On a submaintenance diet, the organ suffered an initial rapid atrophy followed by a more gradual decrease in weight tending to some lower limit.

The kidneys behaved in a similar manner, but the initial rates of change were not nearly so high.

The small intestine, although exhibiting wider variation, followed somewhat similar curves.

WALLACE, L. R.

The Growth of Lambs before and after Birth in Relation to the Level of Nutrition (Part I).

J. Agric. Sci. 1948, **38**, 93-153.

Both the birth weight of the lamb and the milk yield of the ewe are profoundly affected by the level of nutrition of the ewe during the last 6 weeks of pregnancy. By extreme ill-feeding during this period the birth weights of twin lambs may be approximately halved, and on the average each additional $\frac{1}{2}$ lb. of G.D.E.* (as starch) fed in the daily ration over the last month gives an average increase of 1 lb. in the mean birth weight of the twins. The vigour of the lambs is much diminished where the ewes have been inadequately fed before lambing, and the likelihood of losses of both lambs and ewes at lambing time is much increased.

The weight and vigour of the lambs at birth is important, not merely for avoiding losses, but also in enabling the lambs to take full advantage of the potential milk supply of their dams. The capacity of the offspring largely governs the actual yield of milk produced; the lower levels and less pronounced peak of the

* Gross Digestible Energy.

lactation curves for ewes rearing singles as compared to those for ewes with twins, is due to the inability of one lamb to draw off all the milk available during the first few weeks.

The level of milk intake is of great importance for the growth made by the lamb, and at the age of 1 month a value of 0.90 was found for the coefficient of the correlation of the weight increase of the lamb with the milk it had consumed up to that time. Each additional pound of milk that the lamb drinks between birth and 28 days was found to increase the live weight at 1 month by about $\frac{1}{2}$ lb. In the following months the correlation between live-weight increase and milk consumption, though still high, declines progressively, as supplementary feeding also affects the growth made by the lamb, a difference of about 40 lb. in the total G.D.E. from the supplementary food fed during the suckling period leading to a difference of 14–28 lb. in the weight of the lambs at weaning.

The efficiency with which the G.D.E. consumed by the ewe is converted into milk has been examined from several points of view. The gross efficiency depends much upon the live weight and level of milk production of the ewe, and on the stage of lactation; with high-yielding animals during the first month after lambing, little more than $\frac{1}{2}$ lb. of G.D.E. is needed for each pound of milk produced, while for low-producing ewes late in lactation as much as 12 lb. may be required. The quantity of G.D.E. needed by the ewe over and above her maintenance requirements for each pound of milk produced itself increases as lactation proceeds.

WALLACE, L. R.

The Growth of Lambs before and after Birth in Relation to the Level of Nutrition (Part II).

J. Agric. Sci. 1948, **38**, 243–302.

The changes taking place throughout gestation have been observed at monthly intervals in ewes receiving the same standard diet. On a constant level of feeding the weight gains became greater during each succeeding month of pregnancy, and at corresponding stages were larger for ditocous than for monotocous ewes.

Within the tract itself, a study was made of the growth of both maternal and foetal structures. In the first 2 months the major part of the weight increase is due to the enlargement of the uterine wall and the foetal fluids and membranes, while in later stages, although the fluids continue to increase, the growth of the foetus itself accounts for by far the greater part of the gains, and at term forms more than half the total weight of the gravid uterus. The attachment and growth of the cotyledons at the different stages and their distribution in numbers, as well as in weight between the two horns of the uterus, has been described, and comparisons made between the condition in monotocous and ditocous uteri.

The various parts and tissues of the foetus were seen to grow at widely differing rates.

Differences in respect to their manner of growth appear to be to a large extent related to functional necessity. The way by which advanced development at term is achieved may differ in the case of individual organs; for instance, the liver and heart, both of which are presumably of functional importance in foetal life, make a high proportion of their growth in the earliest stages, while others, such as the alimentary tract, not vitally important before birth, make for a higher proportion of their growth in the later stages. Most of the parts and organs of the body are characterised, not by constant, but by changing growth ratios. From this it appears that the type of equation used in studies of allometry cannot be applied with great advantage even within a simple age series. Differences between the parts in respect to rate and time of growth seem to depend largely upon their relative position. This is shown particularly well in the skeleton.

The sheep foetus is composed of parts and organs of different developmental age, some of which between 56 and 84 days are comparatively near, but others already well past their stage of highest specific growth rate. As the later stages of foetal or post-natal development are examined, the order of the parts in respect to specific growth rate changes, so that parts which earlier have the highest rate may later be found to have the lowest.

In the limbs initially the growth gradient runs proximodistally, but the high point of the gradient early becomes more distal, the cannon, at some time prior to 56 days, becoming the site of the maximum growth impulse. During the remainder of the foetal period the growth gradient gradually becomes reversed, so that the growth centre might be described as migrating back up the limb, passing through each bone until, shortly after birth, it is situated in the most proximal part—the girdle—and in post-natal life the parts with the smallest growth ratios are those most distally situated.

This type of descriptive method, however, gives a misleading suggestion that the specific growth rates of certain parts may be increasing as the “wave growth” passes through them; and further, it seems to direct attention too much towards the search for a mysterious growth “impulse” or “centre” passing along the body as the gradients alter, rather than to the study of the whole pattern of growth as it changes.

Actually, with a few exceptions in the case of certain organs, or of parts under particular types of hormone control, the specific growth rates of all the parts of the body considered are declining all the time; and the changing pattern of growth is more readily understood if considered simply in terms of the varying velocities at which the specific growth rates of the different parts fall with increasing age.

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HAMMOND, J. **Milk and Beef. Two Aspects of a Breeding and Rearing Policy.** *Agriculture: J. Minist. Agric.* 1948, **54**, 456–8.

930* MANSFIELD, W. S. **The Future of Beef Production in Great Britain.** *J. Yorks Agric. Soc.* 1947–8, **99**, 36–42.

ASHTON, T.

Technique of Breeding for Drought Resistance in Crops.

Tech. Comm. No. 14. Comm. Bur. Plant Breed. & Genet., Cambridge, 1948. 2s. 6d.

Literature which has bearing upon the problems of breeding for drought resistance in wheat, barley, oats, rice and several other crops is summarized, including papers published in the U.S.S.R.

934* BELL, G. D. H.

The Artificial Production of Polyploids as a Means of Plant Improvement.

Brit. Sci. News, 1948, 1(8), 1-3.

A short general account of the significance of polyploidy in agricultural plants and the use of colchicine. Special reference is made to the importance of amphidiploidy in the Triticineae, with the artificial production if inter-generic and inter-specific hybrids.

BELL, G. D. H.

Crops and Plant Breeding.

J. R. Agric. Soc. 1947, 108, 1-14.

This annual review includes a general discussion of the steps advocated to increase world food production and an account of the improvement of hill and marginal land in Britain. More specific points dealt with are the use of hybrid vigour in plants to increase crop production; yield analysis and breeding in potatoes; yield in sugar beet in relation to virus yellows attack and time of sowing; new varieties in barley and a hitherto unrecorded season abnormality in barley ears; new wheat varieties; oat varieties available for cultivation; and the use of colchicine treatment in plant breeding.

918* HAWKES, J. G.

Classification Breeding and Preservation of the Potato.

Nature, Lond. 1947, 160, 843-4.

An account is given of the discussion on potato breeding and allied problems which took place at a symposium arranged by the Association of Applied Botanists and held in October 1947. The subjects dealt with included the characteristics and use of South American potatoes and the genetics of blight resistance.

HAWKES, J. G.

On the Origin and Meaning of South American Potato Names.

J. Linn. Soc. (Bot.) 1947, 53, 205-50.

A full discussion of the verbal equivalents for the cultivated and the wild potato in the various South American Indian languages is followed by a valuable codification and distribution-study of the native words used in naming the very numerous South American potato varieties.

919* HAWKES, J. G.

The Photoperiodic Reactions of Potato Bolters.

Emp. J. Exp. Agric. 1947, 15, 216-26.

The well-known differences between bolter and normal strains of the two potato varieties Gladstone and Sharpe's Express were shown to be well pronounced, especially in the latter variety. Under long days the bolter plants were significantly taller, matured earlier, flowered more freely, and had longer stolons than the normals. Under short days these differences were completely effaced.

When the bolter plants of Sharpe's Express under long days were allowed to reach full maturity they possessed a larger number of tubers than the normals, though this position was reversed under short days by reason of a greater number of tubers of $\frac{1}{2}$ in. long and under.

The bolters of Sharpe's Express possessed a greater weight of tubers and a larger number of stolons per plant than the normals under long days. These differences were completely removed under short days.

The results obtained show that the bolter when grown under short days is indistinguishable in most of its features from the normal, thus lending weight to the hypothesis that the change from normal to bolter is due to a mutation of one or more relatively unstable genes controlling response to day-length.

According to this view the bolter is a reversion to the more ancestral type of short-day adapted potato such as is found under cultivation in the S. American Andes and from which our own domestic potatoes were probably derived.

932* HAWKES, J. G.

Some Observations on South American Potatoes.

Ann. Appl. Biol. 1947, 34, 622-31.

After discussing briefly the problem of breeding for disease resistance in potatoes, and giving an outline of the work which is in progress at Cambridge on the Empire Potato Collection, the author deals with the taxonomy, distribution and chromosome numbers of the indigenous American potatoes.

948* HOWARD, H. W.

Meiotic Irregularities in Hexaploid Oats.

II. A Cytological Survey of the Variety Picton.

J. Agric. Sci. 1948, **38**, 332-8.

A cytological survey was made of Picton, a winter-hardy variety of oats selected from the cross Argentine x Grey Winter. The variety contains plants which have irregular meiotic divisions.

Two types of irregularities were observed: first, univalents and the products of their divisions; and secondly, bridges and fragments at both first and second division.

Plants selected for a low frequency of irregularities produced offspring with a low frequency of irregular divisions. On the other hand, plants with regular divisions were also obtained from parents which had a high frequency of irregularities.

It is pointed out that the genetical effects of bridge chromatid formation and breakage is the production of gametes deficient for chromosome segments. There is some evidence that chlorotic plants are produced when such deficiencies become homozygous.

It is suggested that the meiotic irregularities produce a certain degree of heterozygosity which may make Picton more adaptable, and at the same time give it a certain degree of hybrid vigour.

927* HOWARD, H. W.

Chromosome Number of *Cardamine pratensis*.

Nature, Lond. 1948, **161**, 277.

The chromosome number of plants of *Cardamine pratensis* L. from four English localities was found to be $n=28$, disagreeing with previous counts of $n=15$ or $n=32$ for English material but agreeing with one of the many chromosome numbers found for this species in Sweden.

909* HOWARD, H. W.

Plant Breeding Progress at Cambridge.

Agriculture: J. Minist. Agric. 1947, **54**, 298-302.

An account is given of the organization and work of the Cambridge University Plant Breeding Institute. Particular attention is given to the new varieties and to the potentially new varieties, usually referred to in the article as selections, bred at the Institute. The relation between the Plant Breeding Institute and the National Institute of Agricultural Botany is also described—briefly this is that one of the many tasks of the N.I.A.B. is to carry out large scale tests of the selections produced by the P.B.I. and, if these tests are satisfactory, to propagate and market the new selections as named varieties.

There are three main lines of wheat breeding: the production of high baking quality winter wheats, the improvement of biscuit quality winter wheats and the breeding of spring varieties. Holdfast was the last high baking quality variety bred by the Institute. By crossing this variety with red-grained wheats, selections have been obtained which have the good quality, high yield and strong straw of Holdfast plus resistance to sprouting in wet harvests. Steadfast, selected from the cross Little Joss x Victor, is the most recent example of a biscuit quality wheat bred by the Institute. New selections of biscuit wheats suited to wet soils have been obtained using Iron as the parent suited to these conditions. The improvement of spring wheat involves crossing them with winter varieties.

Barley breeding can also be considered under three headings: high malting quality spring types, winter types and high yielding feeding barleys. A selection from Spratt Archer, which ripens from 7 to 10 days earlier than that variety, has recently been introduced under the name of Earl. High malting quality spring selections which are early and have short, strong straw have been obtained by crossing English barley with the Danish varieties Kenia and Maja. One of the outstanding new barley varieties is Pioneer which is a winter-hardy, two-row malting type bred from Tschermak two-row x Spratt Archer. Also recently introduced is Prefect, a six-row winter-hardy type suitable for malting. Camton, a dense-eared two-row barley also bred at the Institute, could to a certain extent be used as a high yielding, feeding barley but it has also been used for malting.

The main work with oats has been on winter varieties. By crossing Grey Winter, the standard winter variety which has a weak straw, with Argentina, a spring variety with strong straw, selections have been obtained which have both winter-hardiness and strong straw. Two of these selections, named Resistance (unfortunately later found to be not really winter-hardy) and Picton, have been introduced and further selections are now being tested. In the spring oat breeding programme some attention has been paid to frit fly resistance.

In addition to the three cereals, breeding work was also being carried out with potatoes, spring beans, sainfoin, lucerne, sugar beet and field peas. Potatoes which are immune in the foliage to the three strains of blight (*Phytophthora*) so far found in this country have been bred by crossing wild Mexican potato, the *Solanum demissum* with commercial varieties. Attempts have been made to select for resistance to black fly in spring beans. The object of the sainfoin breeding was to obtain improved types of both the giant and common. Work with sugar beet was started during the war when Britain was cut off from the Continent and it appeared possible that there might be a serious shortage of seed. With the passing of the urgency of the sugar beet seed problem, breeding has been extended by taking into account cluster characters, seedling establishment, biochemical tests and physiological reactions to conditions favourable to bolting. Field peas

which were short haulmed and early maturing have been obtained by hybridization. The multi-podded character has also been incorporated in other selections.

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FYFE, J. L. **The Soviet Genetics Controversy.** *Mod. Quart.* 1947, **2**, 347-51.

928* HAWKES, J. G. **L'autre trésor des Incas.** *Les Musées de Genève.* 1948, **5**, (No. 3).

926* HUDSON, P. S. **British Commonwealth Agricultural Bureaux's Potato Collection.** *Food & Agric.* 1948, **1**, 271-3.

HUDSON, P. S. **Work on the Potato Collection,** 1947. *18th Annu. Rep. Exec. Council. Comm. Agric. Bur.* 1946-7 (1948), 23-5.

PLANT NUTRITION

931* WOODMAN, R. M.

The Growth and Bolting of May King Lettuce.

Agriculture : J. Minist. Agric. 1948, **55**, 63-7.

Statistical experiments have shown that lettuces sown in the period April to early July bolted without hearting. A high level of water encouraged hearting for those sown in January to March. The highest yields were obtained from sowings made in the period August to March, especially with good water supply, hearting up and large heads resulting when growth occurred in short days and cool periods less than 60°F. Irrespective of time of sowing and water supply, the period of greatest bolting was May—July and thus coincided with the longer days and temperatures above 60°F.

PLANT PATHOLOGY

940* DICKINSON, S. & KEAY, M. A.

Growth of *Phytophthora infestans* (Mont.) de Bary on Artificial Media.

Nature, Lond. 1948, **162**, 32.

A method is described for the culturing of *Phytophthora infestans* on a medium containing 2.5% pea-flour, 2.5% sucrose, 1% agar and distilled water. The sucrose, agar and half the water are sterilized at 15 lb. pressure for 15 min., and to this is then added the pea-flour in the rest of the water heated to 40°C. After rapid and thorough mixing the medium is tubed, plugged and sterilized at 10 lb. pressure for 6 min. after an interval of 18-24 hr. The pea-flour is made from garden peas grown in sand under glass and dried at 55-60°C. when the plants are 2-3 ins. high.

PLANT PHYSIOLOGY

DRIVER, C. M.

Vernalization of Seed Potatoes.

Agriculture : J. Minist. Agric. 1947, **54**, 296-8.

SOILS AND MANURES

CHILDS, E. C. & GEORGE, N. C.

Soil Geometry and Soil-Water Relationships.

Discussion of the Faraday Society on *Interaction of Water and Porous Media.* 1948, pp. 78-85.

Shrinkage measurements on clays, together with moisture characteristics, indicate whether such characteristics can be interpreted as indicating the pore size distribution. When such an interpretation is valid, the possibility arises that the permeability, which is determined by the pore-geometry, may be computed from the moisture characteristic, and a simple procedure, based upon random distribution of the pores, is outlined.

Tests of all formulas connecting permeability with porosity are rendered difficult by the usual absence of porosity control. In the present paper such control has been effected by variation of moisture content of the porous material (sand) and a method has been developed for measuring the permeability of such unsaturated materials. Agreement between such measured values and those computed from the moisture characteristics of the same material are reasonably satisfactory, and superior to that obtaining when the computations are based on the too commonly accepted Kozeny type formulas. Moreover, the statistical permeability formula developed here can, in principle, take into account structural features of the porous material and can account for anisotropy, which has hitherto been beyond the scope of permeability theory.

Finally, it is shown how the moisture characteristics and the permeability *v* moisture content curve, taken together, can account for the dependence on moisture content of rate of water movement for a given moisture gradient, and light is thus shown upon such practical but undefinable soil properties as "field capacity"...

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HANLEY, F. **Fertilizers for Combine Drilling.** *Agriculture : J. Minist. Agric.* 1947, **54**, 354-7. *Fertil. Feed. St. J.* 1947, **33**, 689-91.

STATISTICS

913* WISHART, J.

Proof of the Distributions of χ^2 , of the Estimate of Variance, and of the Variance Ratio.
J. Inst. Actuar. Stud. Soc. 1947, 7, 98-103.

Following on a previous paper on "The Variance Ratio Test in Statistics", an elementary proof is given of the random sampling distribution of the sum of the number of squares of independent normal variates. From this is derived the distribution forms for χ^2 and for a variance estimate. The distribution of the variance ratio follows. A note is added on the connection between the probability integral of the distribution and the Incomplete Beta Function.

943* WISHART, J.

Proofs of the Distribution Law of the Second Order Moment Statistics.
Biometrika. 1948, 35, 55-7, 422.

Following yet another proof of the distribution law discovered by the author in 1928, a review is made of the various methods of proof which have been used over the last twenty years. The methods of a paper by Fog are then extended to give a geometrical interpretation of an analytical proof, published elsewhere by the author, of the results needed for a test of significance in the simple regression problem.

WISHART, J.

Statistical Aspects of Demobilization in the Royal Navy.
J. R. Statist. Soc. 1947, 110, 27-50.

A description is given of the "Age and Service Groups" scheme of demobilization set out in Command Paper 6548, and of the statistical machinery required to be set up in the Admiralty both to provide the detailed figures needed in the administration of the demobilization procedure, and to keep records of its progress. The punched card system (Hollerith) of the British Tabulating Machine Company was used. Personnel record cards had to be prepared for each man, and a system devised for keeping the records up to date in spite of hundreds of daily changes. This made it possible to produce automatically, by machine methods, the many routine and special returns called for.

945* WISHART, J.

Tests of Significance in the Simple Regression Problem.
J. Inst. Actuar. Stud. Soc. 1948, 8, 38-43.

The orthogonal transformation used in a previous paper to derive the distribution of χ^2 has its counterpart in a double orthogonal transformation which can be applied to a variable y dependent on another variable x in order to deduce the known tests of significance in the simple regression problem. The algebraic analysis is carried out in this paper, and enables us to deduce the standard results, including the t -distribution, by more elementary mathematical methods than have hitherto been published.

MISCELLANEOUS

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